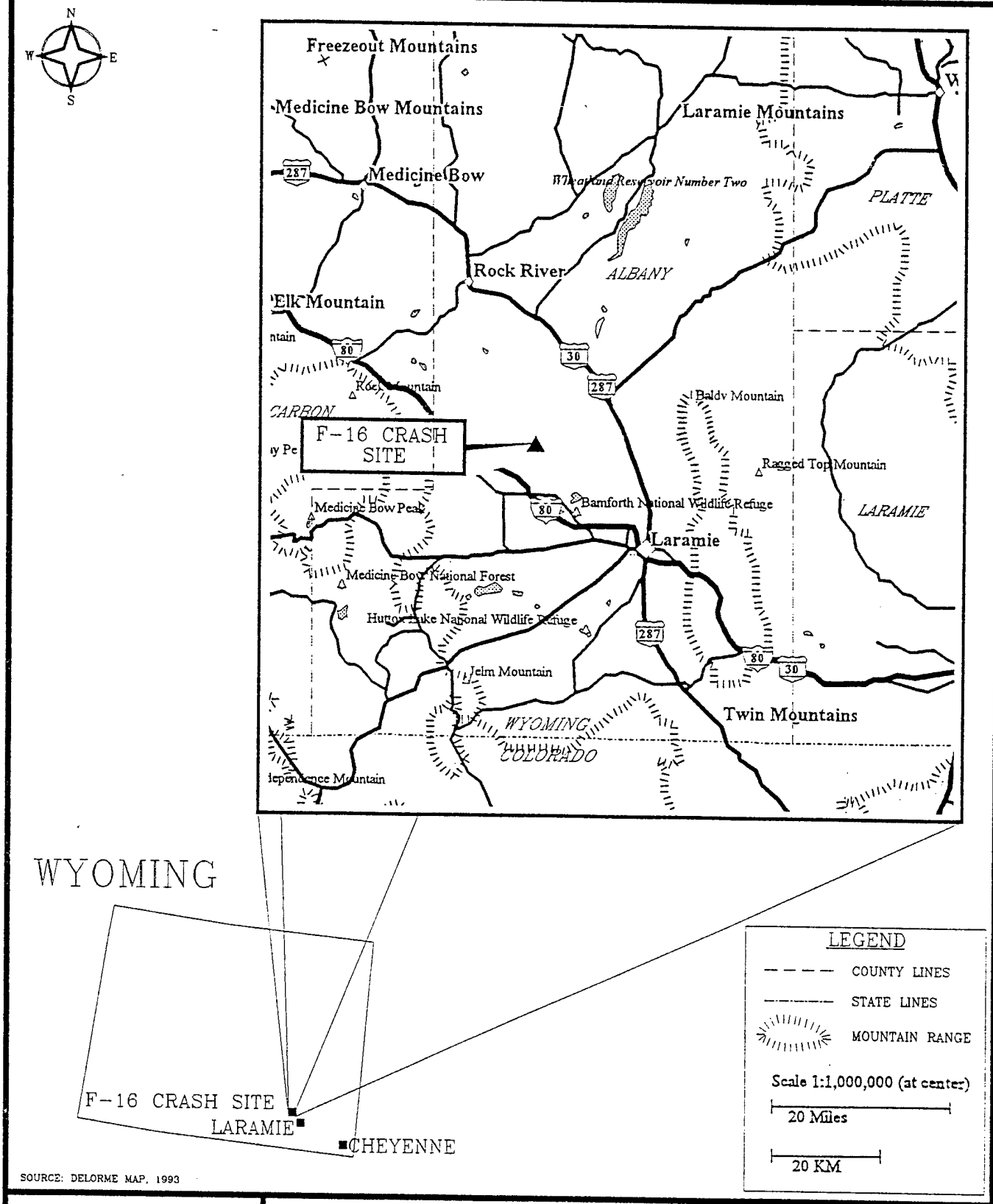
SITE ASSESSMENT REPORT FOR F-16 CRASH SITE ALBANY COUNTY, WYOMING

VOLUME I

140th FIGHTER WING
COLORADO AIR NATIONAL GUARD
BUCKLEY AIR NATIONAL GUARD BASE
AURORA, COLORADO

SEPTEMBER 1996

Prepared For
ANGRC/CEVR
ANDREWS AFB, MARYLAND



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F-16 CRASH SITE LOCATION MAP

F-16 Crash Site
Albany County, Wyoming

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OPERATIONAL TECHNOLOGIES CORPORATION

AUGUST 1996

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Field effort for F-16 crash site in Albany County, Wyoming. Crash occured Nov 93. Push technology was used to determine levels of contamination were below state standards. No further action is necessary at this site

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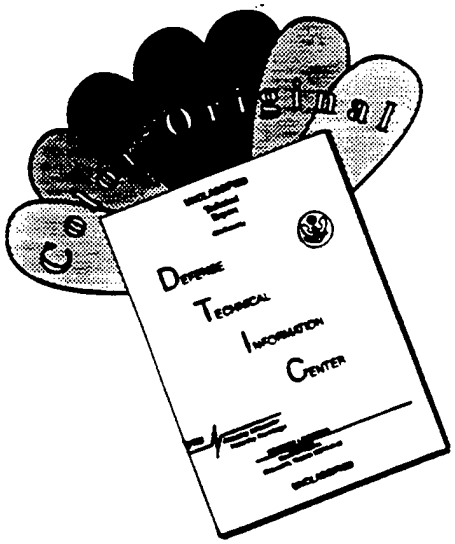

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Prepared By

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LIST OF ACRONYMS

AFB	Air Force Base
AMS/SGPB	Aeromedical Services/Bioenvironmental Engineering
ANG	Air National Guard
ANG/CEVR	Air National Guard/Installation Restoration Program Branch
ANGB	Air National Guard Base
ATHA	Ambient Temperature Headspace Analysis
BG	Background
BLS	Below Land Surface
BTEX	Benzene, Toluene, Ethylbenzene and Xylenes
° C	Degrees Centigrade
CES/CEV	Civil Engineering Squadron, Environmental Management Flight
EPU	Emergency Power Unit
° F	Degrees Fahrenheit
FW	Fighter Wing
gpm	gallons per minute
JP-4	Jet Fuel #4
mg/L	milligrams per liter
MSL	Mean Sea Level
NVGD MSL	National Vertical Geodetic Datum Mean Sea Level
PA	Preliminary Assessment
PID	Photoionization Detector
ppm	parts per million
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
SA	Site Assessment
SB	Soil Boring
SOW	Statement of Work
SP	Soil Probe
TDS	Total Dissolved Solids
TPH	Total Petroleum Hydrocarbons
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound
WDEQ	Wyoming Department of Environmental Quality

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ES 1.0 EXECUTIVE SUMMARY

ES 1.1 INTRODUCTION

A Site Assessment (SA) was conducted at a F-16 Crash site (also referred to as the site) located approximately 25 miles northwest of the City of Laramie, Albany County, in southeastern Wyoming. The crash occurred on 9 November 1993 when an F-16 from the 140th Fighter Wing (FW), Buckley Air National Guard Base (ANGB), Aurora, Colorado, crashed and burned in a remote area of a 97,000-acre cattle ranch owned by Booth Brothers Feed and Livestock Company, Lucerne, Colorado. The aircraft disintegrated and debris was scattered over a large area upon impact (approximately 500 by 2,000 feet), and then burned for an unknown amount of time before firefighters could begin to extinguish the flames (Environmental Compliance Services, 1995). The Site Assessment field work conducted in accordance with the SA Work Plan by Operational Technologies Corporation (OpTech) was conducted from 18 to 22 September 1995.

ES 1.2 PREVIOUS INVESTIGATIONS

The Environmental Management Office, 90th Civil Engineering Squadron, Environmental Management Flight (90th CES/CEV) at F.E. Warren Air Force Base (AFB) conducted an initial assessment of the Crash site in November 1993. OpTech conducted a follow-on interview with 90th CES/CEV personnel involved with the initial assessment. Interviewed personnel indicated that there were no surface water bodies evident on the ground in the vicinity of the site. They described pooling of fluids and staining of soil at approximately eleven locations at the site, as well as visibly burned vegetation in the immediate area. Poor weather conditions, i.e., heavy snow, were also noted at the time of the initial assessment.

As part of the initial assessment, four surface soil samples were collected at the Crash site by the 90th AeroMedical Services/Bioenvironmental Services (90th AMS/SGPB), F.E. Warren AFB. Total Petroleum Hydrocarbons (TPH), using U.S. Environmental Protection Agency (USEPA) Method 418.1 were detected in all four samples, including 800 parts per million (ppm) at one background sampling location. Other detected TPH concentrations included 160, 880 and 98,400 ppm at the initial impact site, the burn area and the engine area, respectively. However, based on concerns identified in the initial assessment Sampling Memorandum (Brannon, 1994), and through interviews with the personnel who performed the sampling, a degree of uncertainty existed about the adequacy of decontamination procedures used between sample collection events and the potential negative effects on the final analytical results. Based on these uncertainties,

the initial assessment Sampling Memorandum recommended that additional sampling and analysis be performed. Therefore, the initial assessment data was not used in developing conclusions about existing contamination at the site or in making future action recommendations. The analytical data used to develop conclusions and recommendations at the site were generated during the September 1995 Site Assessment.

ES 1.3 PRESENT ASSESSMENT

A Kick-Off Meeting, Regulatory Meeting and site visit for the SA occurred from 27 to 28 April 1995. During the site visit, OpTech personnel were accompanied by F.E. Warren AFB personnel who were on-site immediately after the crash and who were involved in the initial assessment. They provided photographs taken immediately after the crash occurred. The photographs showed the fallout pattern of aircraft debris and delineated the burn area that resulted from the crash. These photographs, in conjunction with walking the crash area, enabled the OpTech team to define the site as an area comprising an area approximately 500 by 2,000 feet.

The SA field work began on 18 September 1995 and ended on 22 September 1995. At the commencement of field work, little physical evidence of the crash remained. The majority of burned vegetation had either degraded or been concealed by new plant growth. Overall, vegetation uniformly covered the surface of the site. Two small impressions in the ground, resulting from the crash, were visible. Each of the two impressions was approximately 200 square feet (ft^2), and less than 1 foot in depth.

Soil sampling included a total of 16 soil sample locations for the purpose of delineating TPH contamination (both gas and diesel ranges), and benzene, toluene, ethylbenzene and xylenes (BTEX) contamination. Delineation of these chemical constituents at the site was agreed upon in the Regulatory Meeting, which was attended by representatives of the Wyoming Department of Environmental Quality (WDEQ), Buckley ANGB, and OpTech. Included in the 16 sample locations were three sample locations used to define background levels of TPH and BTEX in the area of the site. Soil samples were obtained from the surface and at five feet below land surface (BLS) at each sampling location. A Geoprobe was used to obtain all soil samples; therefore, a surface sample is defined as soil from the first 8 to 12 inches BLS. Likewise, the sample collected at five feet BLS is representative of the five-to-six-foot BLS soil interval. In addition, one sample location, (Soil Boring 1), was sampled at 5 foot intervals to a depth of 20 feet BLS for purposes of defining local lithology and shallow groundwater conditions. A total of 35 soil samples were collected from the site. Soil sample locations were surveyed and staked by the

90th Civil Engineering Squadron, Engineering Flight (90th CES/CEEC), F.E. Warren AFB. All locations were referenced to National Geodetic Vertical Datum Mean Sea Level (NGVD MSL) with a vertical accuracy of 0.01 feet and a horizontal accuracy of 0.1 feet.

A portable photoionization detector (PID) was used to conduct initial soil sample screening and ambient temperature headspace analysis (ATHA), and a USEPA-certified mobile laboratory was used to conduct quantitative analysis data, including gas and diesel range TPH by USEPA Modified Method 8015, and BTEX by USEPA Method SW8020.

ES 1.3.1 ASSESSMENT FINDINGS

Per the SA Work Plan, the analytes analyzed for included TPH (both gas and diesel ranges) and BTEX. Mobile laboratory analysis of soil samples indicated that neither of these analytes was present in the soils at the site. Accordingly, no State of Wyoming or Federal action and cleanup levels were exceeded at any of the 16 sampling locations.

The 20-foot BLS probe at location SB1 demonstrated that the water table was deeper than 20 feet BLS at the site. Furthermore, groundwater was not detected at any of the other 15 sample locations, each which were sampled to a depth of six feet BLS.

ES 1.4 CONCLUSIONS

No chemicals of concern were found at the site above State of Wyoming or Federal action cleanup levels and analytical detection limits. Therefore, there are no detectable contaminants of concern present at the site.

ES 1.5 RECOMMENDATIONS

Based on the analytical results from the SA, the following recommendation is presented:

- No further action is required.

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SECTION 1.0 INTRODUCTION

This Site Assessment (SA) report presents the results of the field assessment activities conducted at a F-16 Crash site (also referred to as the site) located approximately 25 miles northwest of the City of Laramie, Albany County, in southeastern Wyoming (see Inside Front Cover Figure). The SA was conducted in accordance with the provisions of applicable State of Wyoming environmental regulations, the Resource Conservation and Recovery Act (RCRA), and by the authority of Air National Guard/Installation Restoration Program Branch (ANG/CEVR).

The SA was conducted by Operational Technologies Corporation (OpTech) under contract to the ANG/CEVR (Contract No. DAHA90-93-D-0005, Delivery Order No. 54). The SA Work Plan for the Albany County Crash site was approved by ANG/CEVR in August 1995, and the field work was conducted from 18 to 22 September 1995.

1.1 SA PROJECT OBJECTIVES

The purpose of the SA was to confirm or deny, through field investigation, the presence of total petroleum hydrocarbons (TPH), both gasoline and diesel ranges, and benzene, toluene, ethylbenzene and xylenes (BTEX). Furthermore, SA objectives included determining areal and vertical extent of any contaminants detected, and providing the data needed to reach a decision regarding the need for any further cleanup actions at the site.

1.2 SCOPE OF WORK

The objectives of the SA were met through the performance of field investigation activities, including the collection of soil samples and analysis of these samples for TPH using USEPA Modified Method 8015 and BTEX using USEPA Method SW8020. All analyses were performed by a USEPA-certified on-site mobile field laboratory. Soil sampling and analysis occurred as it was described in the SA Work Plan (OpTech, 1995).

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SECTION 2.0 SITE DESCRIPTION

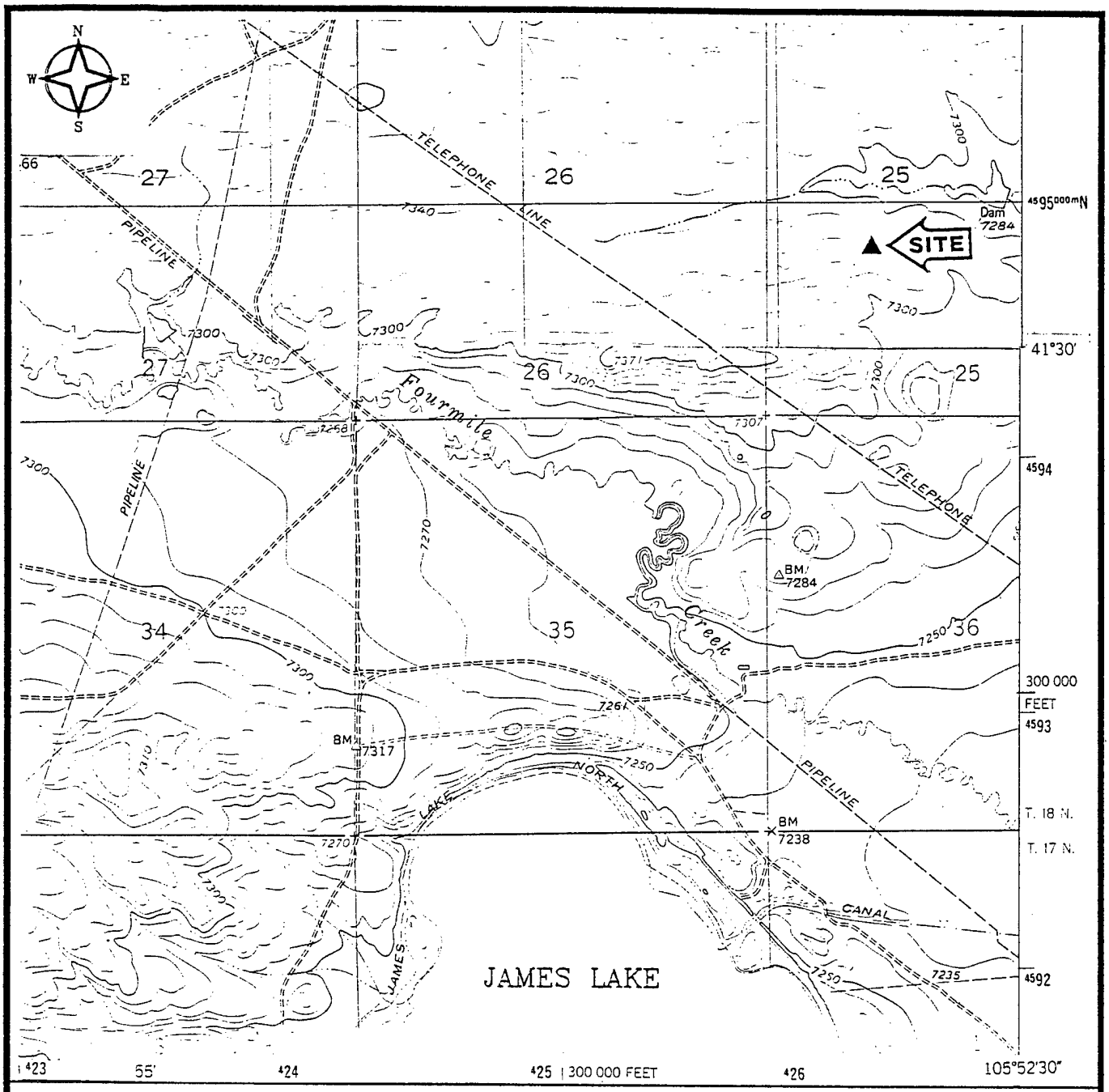
On 9 November 1993, an F-16 fighter aircraft from the 140th Fighter Wing (FW), Buckley Air National Guard Base (ANGB), Aurora, Colorado, crashed into a rural grassland area approximately 25 miles northwest of Laramie, Albany County, Wyoming (see Figure 2.1). The Crash site was located in a remote area of a 97,000-acre cattle ranch owned by Booth Brothers Feed and Livestock Company, Lucerne, Colorado. At impact, the aircraft was estimated to be carrying 1,000 gallons of Jet Fuel #4 (JP-4), 6.7 gallons of hydrazine, 4.5 gallons of synthetic motor oil, 2.0 gallons of November 7808 turbine engine oil, and 5.0 gallons of hydraulic fluid. The aircraft disintegrated and debris was spread over a large area upon impact (approximately 500 by 2,000 feet). The wreckage then burned for an unknown amount of time before firefighters could begin to extinguish the flames (Environmental Compliance Services, 1995).

Hydrazine was not released into the soil as a result of the crash. A Hydrazine Response Team determined that the pilot activated the Emergency Power Unit (EPU) which burned on-board hydrazine for approximately three minutes prior to impact. Four minutes of supplemental power is the maximum time provided by the hydrazine tank during straight hydrazine usage. The hydrazine tank, with a 6.7-gallon capacity, was recovered during the post-crash investigation and found to be rupture free. The tank contained approximately 1.5 gallons, the volume of hydrazine expected after three-minute activation. The tank was removed from the site, and both the tank and hydrazine were appropriately disposed (Crash Site Investigation Report, 1993).

The Chief, Environmental Management, 90th Civil Engineering Squadron, Environmental Management Flight (90th CES/CEV), F.E. Warren Air Force Base (AFB), filed a Substance Release Report for the incident with the Wyoming Department of Environmental Quality (WDEQ), Water Quality Division on 9 November 1993. In addition, the 90th CES/CEV reported the incident to the USEPA National Response Center in November 1993 (Report #WY5571924179).

2.1 ADJACENT LAND USE

The Crash site is located in a rural section of a 97,000 acre cattle ranch. The site is approximately six miles off the main highway (U.S. Interstate 80) and can only be reached using high-clearance vehicles. The large acreages of land surrounding the site are used as livestock pastures. There are no concentrated residential areas within a 2 mile radius of the site.



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SOURCE: USGS – BIG JUDSON AND JAMES LAKE, WYOMING QUADRANGLE SHEETS (1981 AND 1978 RESPECTIVELY).

FIGURE 2.1

WYOMING\PORTRAIT

CRASH SITE LOCATION AND TOPOGRAPHY

F-16 Crash Site
Albany County, Wyoming

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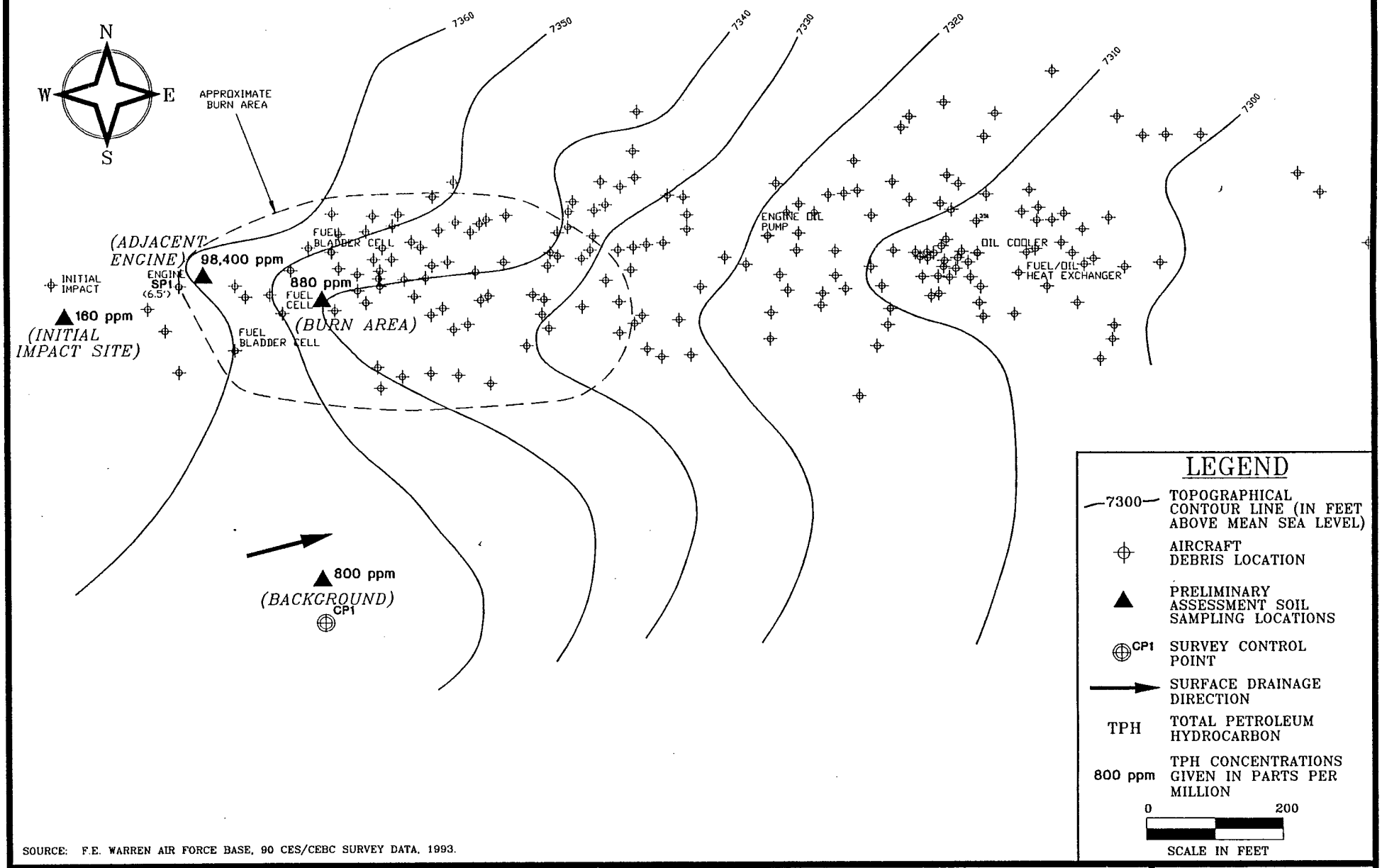
2.2 PREVIOUS INVESTIGATIONS

The 90th CES/CEV, F.E. Warren AFB conducted an initial assessment of the site in November 1993. OpTech conducted a follow-on interview with personnel involved with the initial response and initial assessment. Interviewed personnel indicated that there were no surface water bodies evident on the ground in the vicinity of the site. They described pooling of fluids and staining of soil at approximately eleven locations at the site and visibly burned vegetation in the immediate area. Poor weather, i.e., heavy snow, was also noted at the time of the initial assessment.

As part of the initial assessment, four surface soil samples were collected at the Crash site by the 90th AeroMedical Services/Bioenvironmental Engineering (90th AMS/SGPB), F.E. Warren AFB. TPH, using USEPA Method 418.1, were detected in all four samples, including 800 parts per million (ppm) at one background sampling location. Other detected TPH concentrations included 160, 880 and 98,400 ppm at the initial impact site, the burn area and the engine area, respectively (Figure 2.2). However, based on concerns identified in the initial assessment Sampling Memorandum, and through interviews with the personnel who performed the sampling, a degree of uncertainty existed about the adequacy of decontamination procedures used between sample collection events and the potential effects on the above analytical results. Based on these uncertainties, the initial assessment Sampling Memorandum recommended that additional sampling and analysis be performed. Therefore, the initial assessment data was not be used in developing conclusions about existing contamination at the site or in making future action recommendations for the site. The analytical data used to develop conclusions and recommendations at the site were generated during the September 1995 Site Assessment.



SOURCE: F.E. WARREN AIR FORCE BASE, 90 CES/CEBC SURVEY DATA, 1993.

FIGURE 2.2

WYOMING\SAMPLOC2

PRELIMINARY ASSESSMENT SOIL SAMPLING LOCATIONS

F-16 Crash Site
Albany County, Wyoming

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SECTION 3.0 ENVIRONMENTAL SETTING

The site is located in a rural grassland prairie approximately 25 miles northwest of Laramie, Wyoming at approximately 41 degrees (°), 30 minutes (') and 9 seconds (") North Latitude and 105°, 53' and 12" West Longitude in Albany County (Township 18 N, Range 76W, Section 25). This region of southeastern Wyoming (the Laramie Basin area), is characterized by large tracts of rolling grasslands dissected by large northwest-to-southeast trending mountain ranges and streams. The site is bordered to the east by the Baldy Mountain (approximately 20 miles east) and to the west by the Medicine Bow Mountains, one of the ranges of the Rocky Mountains (approximately 10 miles west). The primary use of the grasslands surrounding the site is cattle ranching.

3.1 PHYSIOGRAPHY AND CLIMATE

The region surrounding the site is part of the Laramie Basin, which comprises most of Albany County. The Laramie Basin is a wide rolling plain located between the Laramie Range on the east and the Medicine Bow Mountains on the southwest. To the northwest are the Freezeout Hills, various high ridges and the valley of the Medicine Bow River (see Inside Front Cover Figure).

The altitude of the Laramie Basin varies from about 7,000 feet above mean sea level (MSL) in its northern and central portions to 7,500 feet above MSL near the Colorado border. The length of the basin is approximately 90 miles, and has a maximum width of about 30 miles. Although the Laramie Basin exhibits considerable variety in configuration, it consists mostly of broad, shallow, terraced valleys separated by low, flat-topped ridges which are remnants of an earlier terrace system (Darton and Siebenthal, 1909).

The climate of the Laramie Basin is typical of the northern Rocky Mountains and the higher Great Plains. It is moderately dry and cool, relatively uniform from year to year, and has a large percentage of sunshine. Daily temperatures average approximately 29° F in the Winter, 38° F in the Spring, 62° F in the Summer, and 52° F in the Fall. The relative humidity averages nearly 50 percent on an annual basis.

The average annual "water equivalent" precipitation amount is 14.7 inches, with an average of 9.1 inches of this average occurring in May through August. Rainfall intensity is often high from May to August, with an average of 12 thunderstorms per month. Average annual snowfall is approximately 55 inches, with 47 inches of this average occurring from November to April.

However, it is not uncommon to have heavy snow in May. The snowfall amounts are incorporated into the average annual "water equivalent" amounts (National Climatic Data Center, 1993). Free water surface evaporation is approximately 62.8 inches per year, resulting in a net precipitation of -48.1 inches per year (National Oceanic Atmospheric Administration, 1982).

Windy days are quite frequent during the Winter and Spring months. The average annual wind speed is almost 13 miles per hour (mph), with no single month average wind speed below 10 mph. Since the wind is usually the strongest during the daytime, it is a very noticeable weather element. Usually the strong winds are from a westerly direction, and this tends to raise the temperature because the air is moving downslope. Furthermore, the mountains to the west are effective moisture barriers, contributing to the semi-arid climate. (National Climatic Data Center, 1995)

3.2 REGIONAL AND LOCAL GEOLOGY

The Laramie Basin is a broad syncline trending north and south with gently dipping bedding on the east side and steeply dipping bedding and faulting on the west side. The Basin lies between the uplifts of the Laramie Mountains on the east and the Medicine Bow Mountains and minor ranges on the west. The Basin's depth is such that it contains about 7,000 feet of Paleozoic and Mesozoic sedimentary rocks, from Carboniferous to late Cretaceous in age, as well as extensive Tertiary and Quaternary alluvium and high-terrace mantle deposits (Darton and Siebenthal, 1909). The Precambrian granitic basement rocks are overlain by sedimentary rocks of Pennsylvanian age which are in turn overlain by a rather complete succession of late Paleozoic and Mesozoic rocks. Only the Paleocene, Eocene, and Quaternary epochs of the Cenozoic Era are definitely represented (Blackstone, 1973). Extensive deposits of Quaternary age are present in the Laramie Basin as alluvium and high-terrace mantles, representing various stages of topographic development (uplifting and subsidence) of the region. A small amount of glacial drift (till and boulders), resulting from a glacier that once descended from the Medicine Bow Mountains, also occurs (Darton and Siebenthal, 1909).

The predominant stratigraphic unit present in the Laramie Basin area is the Wind River Formation. The formation consists of Tertiary age deposits of variegated claystone, sandstones, and conglomerates. The matrix is a coarse-grained sandstone grading to conglomerate. Visible clasts range upward in size. On the basis of surface outcrops, dips, and other records, the Wind River Formation has an approximate thickness of 400 feet (Blackstone, 1973).

The geology of the strata underlying the site area is characterized by shales and sandstones of the Cretaceous-age Montana Group, which consists of two parts (upper and lower). The Montana Group outcrops are numerous and extensive; they occupy a broad basin west and north of Laramie and a smaller area in the basin of Little Medicine Bow Creek. The site rests on the upper part of the Montana Group. The upper part consists of a bed of moderately hard gray sandstone about 60 feet thick. This prominent bed of sandstone is overlain by shale and beds of coal. The materials in the northern part of the area are mainly sands and sandstones or conglomerates (Darton and Siebenthal, 1909). Figure 3.1 and Figure 3.2 present the geology of the site and the surrounding area. Two different geology maps, from two authors, are presented in order to depict the geology in the region around the site. Figure 3.1 is taken from the James Lake Quadrangle Map and shows the region just south of the site. Figure 3.2 is taken from the Big Judson Quadrangle Map and shows the site and the area to the north of the site.

Figure 3.3 presents pertinent information as to the formations present, their lithologic characteristics and thickness, and significant features within the general area of the site, specifically, the James Lake Quadrangle. The stratigraphy represented in Figure 3.3 is exclusive of the underlaying Precambrian rock.

3.3 SOILS

The area surrounding the site, as identified by the Cheyenne Field Office of the Soil Conservation Service of the U.S. Department of Agriculture (USDA), is classified as Tisworth-Gerdrum Family Complex (0-6% slopes), which is a sandy clay loam soil (Figure 3.4). (The Soil Conservation Service Field Office of the USDA, located in Cheyenne, does not offer a published Soil Survey or published Soils Map; the copy which is provided is a "working copy" for field office investigations.) This unit is on fan terraces, toe-slopes, and in areas of valley fill (Soil Conservation Service, 1995). The native vegetation at the site consists of low grasses and sagebrush. No trees of any type grow in the vicinity of the site.

The Tisworth-Gerdrum complex is 45 percent Tisworth sandy clay loam and 40 percent Gerdrum sandy loam. It is formed in alluvium derived dominantly from mixed sources. Typically, the surface layer is light yellowish brown sandy clay loam about 2 inches thick. The subsoil is yellowish brown clay loam about 11 inches thick. The substratum is light yellowish brown clay loam to a depth of 60 inches or more. The soils in this unit are well drained. Permeability is very slow to slow. The available water capacity is high. Available water capacity describes the capacity of the described soil to provide life sustaining water amounts to vegetation. This unit is not considered to be highly erodible (Soil Conservation Service, 1995).

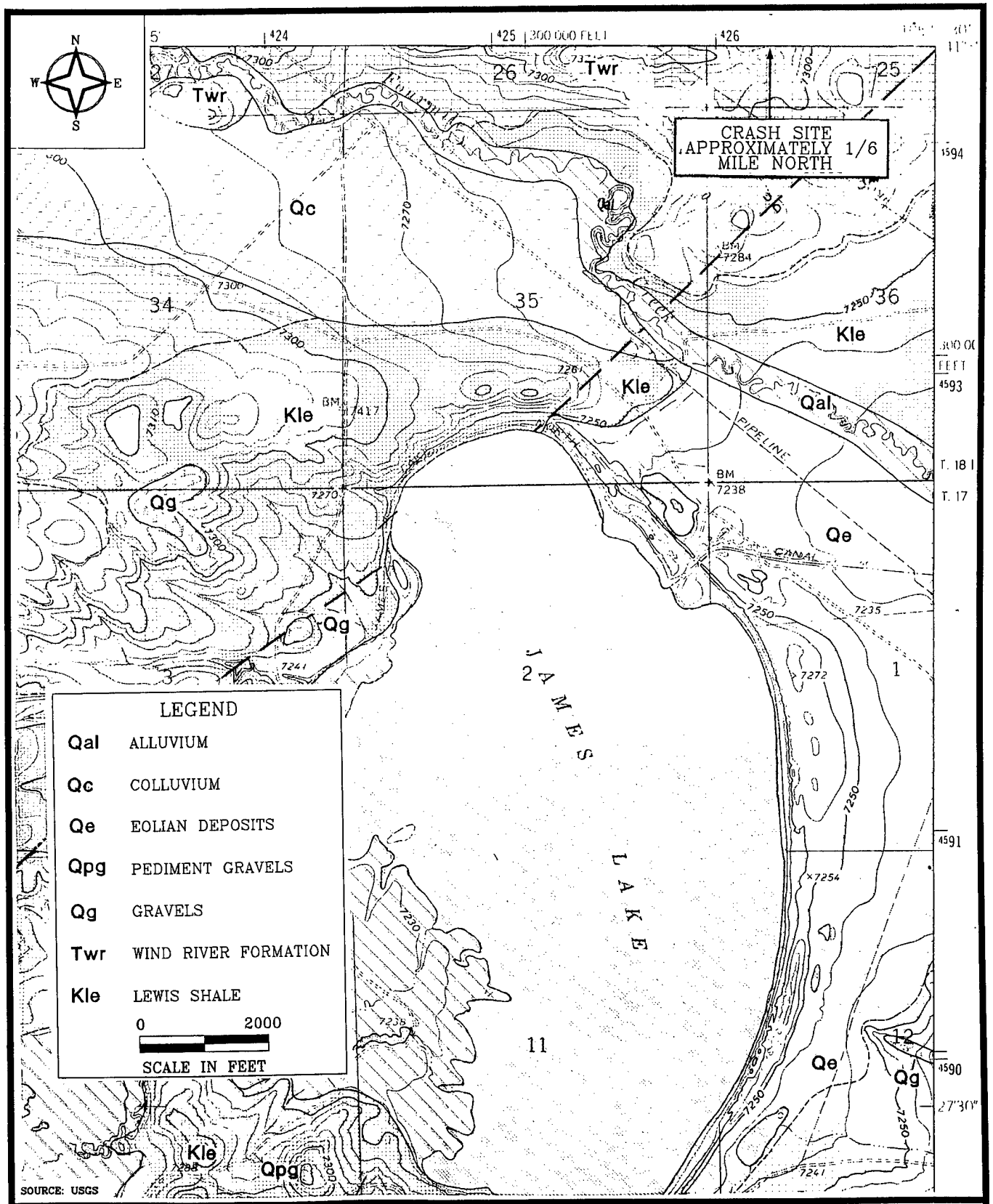

FIGURE 3.1

WYOMING\SOIL-MAP

GEOLOGIC MAP
JAMES LAKE QUADRANGLE
F-16 Crash Site
Albany County, Wyoming

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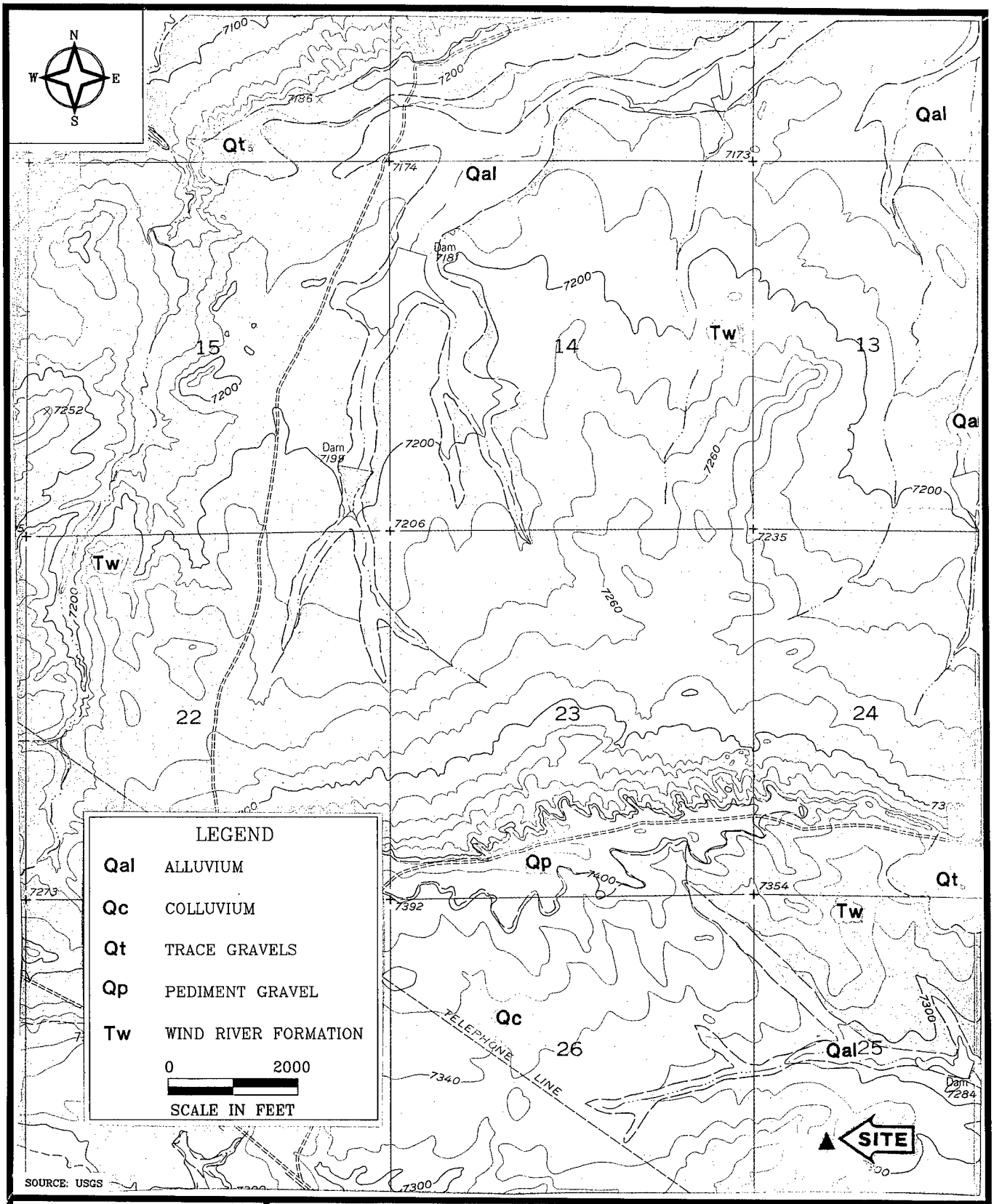

FIGURE 3.2

WYOMING\SOIL-MAP

GEOLOGIC MAP
BIG JUDSON QUADRANGLE
F-16 Crash Site
Albany County, Wyoming

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Age			General Lithology	Thickness
CENOZOIC	Quaternary	Recent	Alluvium, colluvium and landslide deposits, eolian deposits, and stream gravels.	
		Pleistocene	High level boulder deposits, pediment gravels, glacial till(?), mass gravity deposits, and boulder terrace deposits.	
	Tertiary	Olig. (?), Mio. (?) Plio. (?)	Tertiary undivided - Tuffaceous siltstone, sandstone, and conglomerate.	200'+
			Major unconformity	
		Eocene	Wind River Formation - Variegated claystone, sandstones, conglomerates.	400'+
			Major unconformity	
		Paleocene	Hanna Formation - Basal conglomerate with quartzite boulders, arkosic sandstones, fossil wood.	800'+
			Major unconformity	
MESOZOIC		Cretaceous	Medicine Bow Formation - Sandstones, shales, carbonaceous shale, coals, ironstones. Pelecypod fauna. Only basal part present.	400'+
			Fox Hills Sandstone - Sandstone, gray, fine grained. Mapped with Lewis shale.	2200-2600'
			Lewis Shale - Shale, gray, marine, containing sandstone, fine grained, soft, local concretion zones.	
			Mesaverde Formation - Pine Ridge Sandstone Member at top (coal bearing). Sandstones brown, siltstones, and gray shales. Thick, yellow weathering sandstones near base.	1200-1300'
			Steele Shale - Shale, gray, marine. Persistent sandstone 1300' above base has been locally called "Shannon" sandstone.	2600'+
			Niobrara Formation - Calcareous shale with three well defined marlstone units.	500'
			Frontier Formation - Wall Creek Sandstone Member at top, "salt and pepper", sandstone, chert pebbles and shark teeth (at base). Shale gray, changing to black at base. Septarian concretions in basal shale.	10' 450'
			Mowry Shale - Shale, siliceous, weathers silver gray. Fish scales common. Numerous bentonite layers.	150'
			Muddy Sandstone - Sandstone, medium grained.	20'
			Thermopolis Shale - Shale, black, marine containing thin lenticular olive green sandstone layers.	110'

SOURCE: BLACKSTONE, D.L., 1973.

FIGURE 3.3

WYOMING\STRAT

STRATIGRAPHIC UNITS OF THE JAMES LAKE QUADRANGLE (GENERAL AREA OF CRASH SITE)

F-16 Crash Site
Albany County, Wyoming

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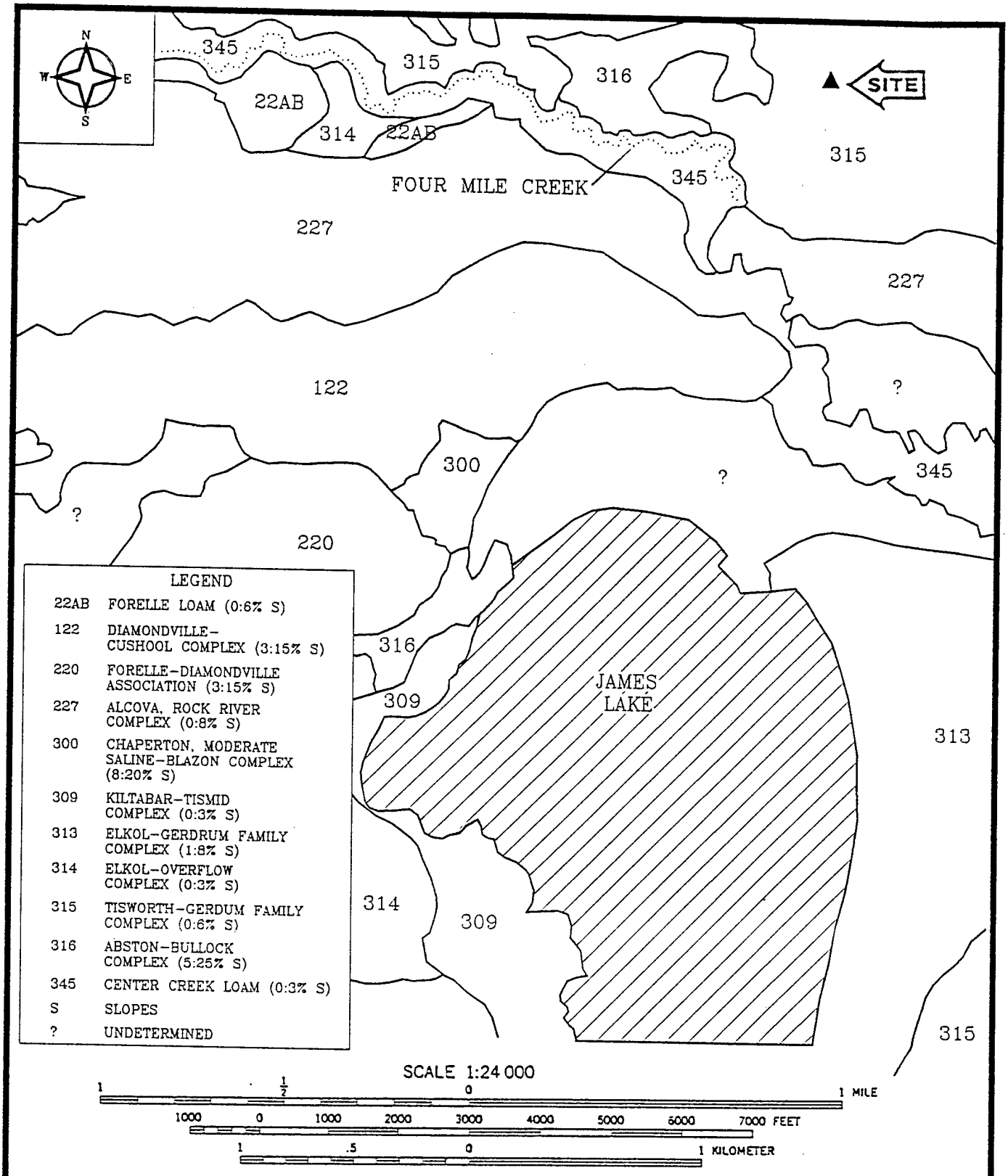

SOURCE: USDA, SOIL CONSERVATION SERVICE, 1995.

FIGURE 3.4

WYOMING\SOIL-MAP

SOILS MAP OF
CRASH SITE LOCATION

F-16 Crash Site
Albany County, Wyoming

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3.4 HYDROGEOLOGY

Occurrence of groundwater in the area of the site is controlled by the soil, lithology, and structural geology. Formations composed, in part, of sand or coarser material will yield water to wells because of primary (intergranular) permeability. The yield of water from sandstone will depend on the size and sorting of the grains and the cementation between the grains. Primary permeability occurs only in the clastic sedimentary rocks.

Secondary permeability, which results primarily from fracturing and (or) solution, occurs in consolidated rocks and is most apt to be present in the vicinity of folds and faults. However, in some areas rocks near folds and faults may be less permeable because of compaction during deformation or cementation by mineralized fluids. Of the yields tabulated through 1968 in the Laramie Basin area, all of those wells and springs in the order of 100 gallons per minute (gpm) or more occur in consolidated rocks and are attributed to secondary permeability (Lowry, et al, 1973).

The quality of groundwater in the Laramie Basin area differs not only between aquifers, but also within a given aquifer and is the result of three dominant changes – solution, cation exchange, and sulfate reduction. As a part of the investigation process, a well inventory was obtained from the Wyoming State Engineer's Office. However, water quality analysis reports for wells in the region of the site are not provided with the well inventory. Many of these reports are unattainable, as the State office does not require that a water quality analysis report be submitted by the proprietor as part of the permit process.

However, based on interviews with the property manager of the land where the crash occurred, many of the wells produce water with a "rotten-egg" odor. Sulfate reduction is therefore the suspected primary reaction occurring in groundwater near the site. Sulfate reduction is the process by which sulfate is reduced in the presence of hydrocarbons. This reaction accounts for the presence of hydrogen sulfide (H_2S), which is responsible for the "rotten-egg" odor in the well water. The reaction also produces high bicarbonate concentrations. Reports indicate that total dissolved solids (TDS) concentrations range from 300 to 9,700 milligrams per liter (mg/L) (Lowry, et al, 1973). However, this is a range estimate for the Laramie Basin as a whole.

The Wyoming State Engineer's Well Inventory estimates the majority of water wells in the Laramie area, including the region surrounding the site, range from 120 to 1,500 feet deep. Information provided by the Well Inventory indicates that there are no water wells (domestic or stock) located on or near the site. The closest stock-use water wells are located approximately

2 miles from the site. Wells in the surrounding area are primarily used for stock supply. Of the 39 wells listed in the State Well Inventory (see Table 3.1), 33 are solely for stock use, 5 are for stock and domestic use combined, and only 1 was developed solely for domestic use. The 4 wells within approximately 2 miles of the site are for stock watering and were developed to depths ranging from 150 feet to 300 feet. In general, groundwater suitable in quantity and quality for stock use is available at depths between 120 feet and 500 feet (Lowry, et al, 1973).

Table 3.1
Water Well Inventory in General Area of the Site
F-16 Crash Site, Albany County, Wyoming

No.	Location (R/S/Q)	Permit No.	*Approx. Dist.	Use Code	Yield (gpm)	Depth (ft)
1	74/26/NENE	P10333W	14	STO	10.00	1250.0
2	74/26/NENE	P40103W	14	DOM	5.00	200.00
3	74/27/NWSE	P26672W	11	STO	3.50	115.00
4	74/30/NWSW	P18440P	10	STO DOM	7.50	130.00
5	74/30/SWNW	P26673W	9	STO	UNK	120.00
6	74/32/SENW	P18432W	14	STO	7.50	16.00
7	74/34/NWNW	P17651P	12	STO DOM	10.00	20.00
8	74/34/NWNW	P1572W	12	STO	NA	NA
9	75/1/NWSE	P18431P	5	STO	7.50	60.00
10	75/1/SENE	P15990P	8	STO	5.00	300.00
11	75/4/SWNE	P21901W	4	STO	10.00	200.00
12	75/6/NWNW	P16480P	5	STO	5.00	300.00
13	75/6/NWNW	P16481P	5	STO	5.00	300.00
14	75/8/NESW	P16479P	6	STO	5.00	300.00
15	75/9/NWNW	P21903W	5	STO	7.50	175.00
16	75/9/SESE	P15986P	8	STO	4.00	220.00
17	75/17/NENW	P16025P	7	STO	5.00	220.00
18	75/18/NWNE	P82895W	6	STO	5.00	160.00
19	75/22/NESE	P15987P	8	STO	5.00	160.00
20	75/23/SESW	P18429P	6	STO	7.50	60.00
21	75/25/NENW	P28901W	7	STO	4.00	180.00

Table 3.1 (Concluded)
Water Well Inventory in General Area of the Site
F-16 Crash Site, Albany County, Wyoming

No.	Location (R/S/Q)	Permit No.	*Approx. Dist.	Use Code	Yield (gpm)	Depth (ft)
22	75/29/SESE	P15988P	8	STO	5.00	300.00
23	75/31/NENE	P4817P	9	STO DOM	7.50	42.00
24	75/33/NWNE	P16191P	6	STO	10.00	300.00
25	75/34/SWSE	P15989P	3	STO	7.00	180.00
26	76/5S/WSW	P15991P	4	STO	5.00	300.00
27	76/6/NESE	P5144W	3	STO	5.00	200.00
28	76/6/SESE	P15992P	2	STO	5.00	300.00
29	76/6/SESE	P15993P	2	STO	5.00	300.00
30	76/7/NENW	P15994P	3	STO	10.00	35.00
31	76/8/NWNE	P16478P	4	STO	5.00	300.00
32	76/8/NWNW	P15995P	7	STO	5.00	300.00
33	76/8/SENW	P5141W	2	STO	8.00	150.00
34	76/13/NWSE	P16732W	3	STO	NA	NA
35	76/31/NENW	P15996P	3	STO	5.00	200.00
36	76/32/NENE	P4810P	3	STO DOM	10.00	200.00
37	76/33/SENE	P15997P	2	STO	5.00	175.00
38	77/1/SESE	P18535P	5	STO DOM	24.00	10.00
39	77/1/SWNE	P15998P	10	STO	5.00	300.00

gpm – gallons per minute.
ft – feet.
STO – Stock use.
DOM – Domestic use.
R/S/Q – Range/Section/Quarter.
* – Approximate distance from Crash site.
Source: Wyoming State Engineers Office, 1995.
NA – Data Not Available.

SECTION 4.0 FIELD PROGRAM

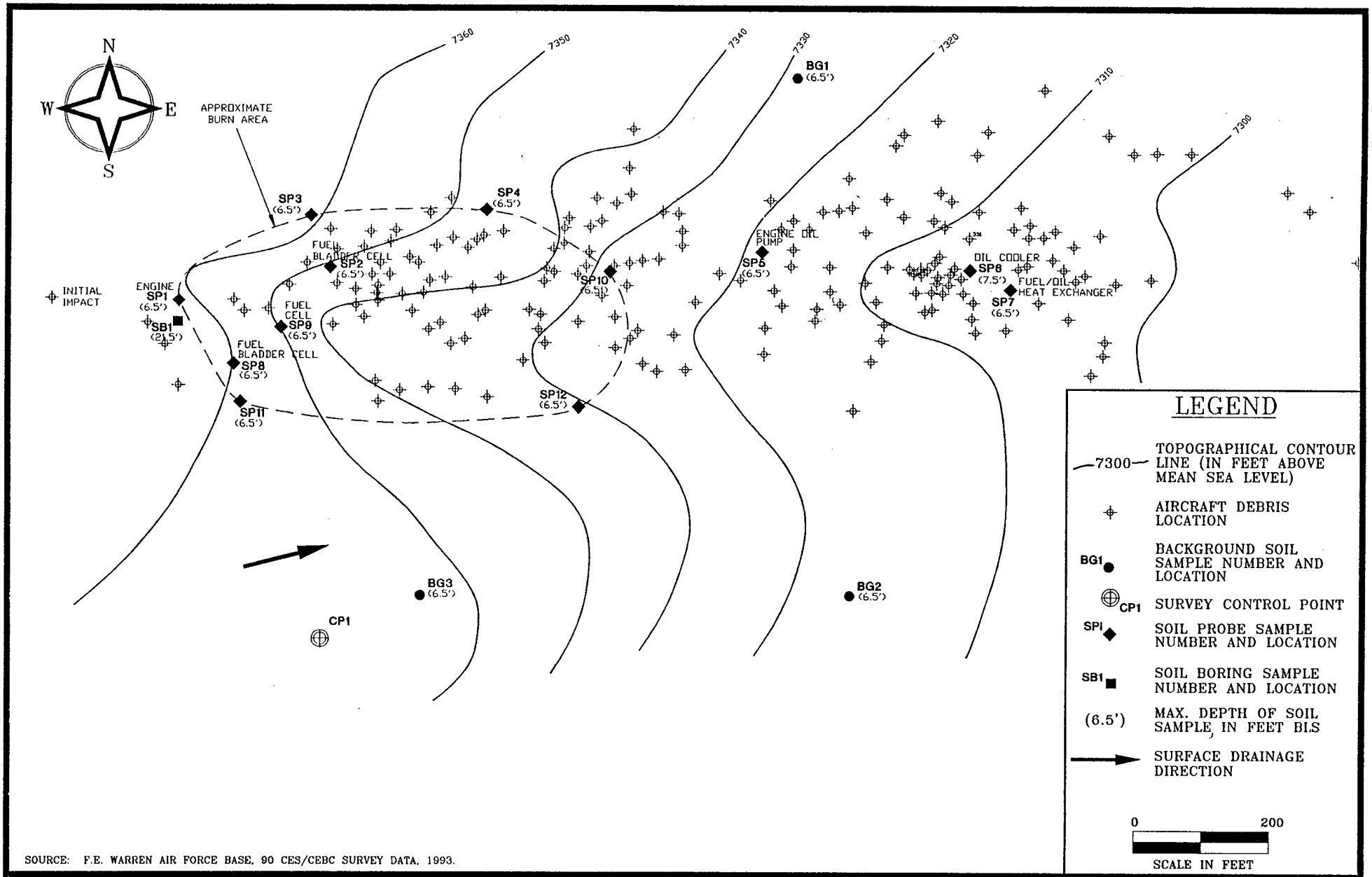
This section describes field investigation activities performed and methodologies used during the SA to accomplish the project objectives.

4.1 SUMMARY

An initial sampling grid, comprised of 15 sampling points, was established in the SA Work Plan. The grid was believed to be sufficient to delineate targeted soil contamination at the site. The 15 sampling locations were comprised of 12 investigative locations (sample point one (SP1) through twelve (SP12)) and three soil background locations (Background one (BG1) through three (BG3)). The grid was based on aircraft debris fall-out locations, identifiable burn locations and PA findings (particularly analytical results and comments on soil staining locations). Based on the results of the analysis of soil samples from the primary sampling grid, the field team had selected and surveyed contingent sampling locations in the event that they were needed to more completely delineate, both arealy and vertically, all identified contamination.

The first step of the field program consisted of identifying, surveying and staking soil sampling locations. All soil sampling locations are depicted in Figure 4.1. A surveying crew from the 90th CES/CEEC, F.E. Warren AFB provided the surveying services for the SA. On the first day of field work, 18 September, 1995, all soil sampling locations, planned and contingent, were surveyed and staked prior to initiating any sample collection activities. The 90th CES/CEEC performed the initial surveying for aircraft part locations immediately after the crash occurred, and therefore were aware of the site layout, including their original control point locations. All surveyed points were referenced to National Geodetic Vertical Datum Mean Sea Level (NVGD MSL) with a minimum vertical accuracy of 0.01 feet and a horizontal accuracy of 0.1 feet.

On 19 and 20 September 1995, the focus of the field team was on the collection, screening and analysis of surface and subsurface soil samples. Each of the 15 primary soil sample locations were sampled at the surface and at 5 feet below land surface (BLS), for a total of 30 soil samples. In addition to the 15 primary sample locations, 1 soil sampling location (Soil Boring 1 (SB1)) was established and sampled in 5-foot intervals to a depth of 20 feet BLS. This was performed exclusively for examining lithology and confirming the presence or absence of shallow groundwater. However, analysis for contaminants was still performed on these soil samples. Therefore, a total of 35 soil samples were collected and analyzed.



SOURCE: F.E. WARREN AIR FORCE BASE, 90 CES/CEBC SURVEY DATA, 1993.

FIGURE 4.1

WYOMING\SAMPLOC

CRASH SITE SOIL SAMPLING LOCATIONS

F-16 Crash Site
Albany County, Wyoming

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Suspected contamination at the site, discussed in Section 1.2, focused on BTEX components and TPH (both gasoline and diesel ranges). Therefore, a photoionization detector (PID) was used for initial sample screening. A USEPA-certified on-site mobile laboratory was used for quantification of soil contamination, using USEPA Method SW8020 for BTEX components and USEPA Modified Method 8015 for TPH. Mobile laboratory analysis of soil samples indicated that there were no contaminants of concern above analytical detection limits in the soils at the site. Therefore, additional contingent soil sample locations were not necessary.

The field team made its final visit to the site on 21 September, 1995, for the purpose of cleaning up the site area, including removing soil sample location stakes and other investigation debris.

4.2 DEVIATIONS FROM THE WORK PLAN

Two deviations from the SA Work Plan were noted. These deviations did not prevent the overall objectives of the SA from being accomplished.

First, soil sample transport and custody was not performed in a manner identical to that described in Subsection 4.5.2 of the SA Work Plan. Due to the close proximity of the mobile laboratory, the refrigerator within the mobile laboratory was used to store samples as opposed to an ice chest. At least one of the field team members was with the mobile laboratory during the entire work day, and at night the laboratory was securely locked.

Secondly, ambient temperature headspace analysis (ATHA) was not performed in a manner identical to that described in Subsection 4.4.1.2 of the SA Work Plan. The soil to be used for performing each ATHA was placed into a small glass sample jar, sealed with aluminum foil and capped, as opposed to being sealed in a plastic bag. This change was made to remove any chance of picking up volatile components that may have originated from the plastic bag itself, as well as ensuring a more uniform distribution of volatile components throughout the headspace sampling volume. All other aspects of conducting ATHA followed the SA Work Plan.

4.3 SAMPLE COLLECTION ACTIVITIES

Soil samples were obtained using a hydraulic Geoprobe. Soil sampling probes consisted of one- to four-foot lengths of 3/4 inch-diameter hollow steel pipe. Individual pipe lengths were combined to create the desired sample depth. A large-bore hollow tube sampler was attached to the end of the probe to collect each soil sample. The tube sampler consisted of a sample tube with an inner acetate sleeve. A smaller diameter rod, with a drive tip, was fitted inside the tube

sampler. The probe was hydraulically pushed to the desired depth. Once the desired depth was reached, the drive tip was loosened. The sample apparatus was then pushed approximately 12 inches into the soil, causing the sleeves to become packed with soil. Hydraulic power was then used to retrieve the sample from the ground. This procedure was used successfully at every sampling location on the site.

Decontamination of the hollow tube sampler and the acetate sleeves was performed prior to taking each sample. Decontamination was performed by washing the equipment in an Alconox™ and water solution followed by a triple rinse (potable water, deionized water, and methanol).

4.4 FIELD SCREENING ACTIVITIES

A PID was used to screen bore holes as soon as the soil sample had been removed from the ground and to conduct ATHA for volatile organic compounds (VOCs). In addition, the PID was used as a health and safety monitor of breathing zone air quality for field team personnel. The PID was calibrated daily using a 100 ppm isobutylene standard.

Once the soil sample was prepared for mobile laboratory analysis, an ATHA was conducted on the remaining soil. On day one of sampling, the ambient temperature was approximately 65° F, and ATHA was conducted by placing the foil covered glass sample jar in a location where it received full sunlight for 15 minutes, thus allowing it to reach approximate ambient air temperature. On the second sampling day, the ambient temperature was approximately 30° F, and the glass sample jar was placed in the heated cab of a truck to ensure that 60° F was achieved for ATHA. After approximately a 15-minute period, the headspace measurement was obtained and recorded using a PID. A listing of ATHA results is given in Table 5.2 and Appendix A.

4.5 FIELD ANALYTICAL ACTIVITIES

Based on requirements of the Statement of Work (SOW) and in compliance with the State of Wyoming, soil samples were analyzed for BTEX by USEPA Method SW8020, and TPH by USEPA Modified Method 8015. The mobile lab was operated and standardized in conformance with USEPA SW846 guidelines.

Analytical quality assurance/quality control (QA/QC) procedures included the analysis of field duplicates, field blanks and equipment blanks. Field blanks were used to check for procedural contamination and ambient conditions at the site that may have caused sample contamination.

Duplicate samples were submitted to provide a quality assurance check on analytical procedures and results. All samples were surrogate spiked and recoveries reported.

Analytical results obtained from mobile laboratory analysis are summarized in Subsection 5.4.2. Chromatograms, including QA/QC data, are included as Appendix B.

4.6 INVESTIGATION DERIVED WASTE

During the SA, liquid wastes containing water and methanol, used to decontaminate sampling equipment and glass holding jars, were generated as a result of field activities. Drill cuttings were not generated during the collection of soil samples due to the sampling method employed. The total volume of investigation derived wastes generated was contained within a single 55-gallon drum.

Prior to the commencement of field work, arrangements had been made with the Wyoming Air National Guard (ANG), 153 Air Lift Group, Cheyenne ANGB, Cheyenne, Wyoming, to temporarily store the waste until the Colorado ANG could make arrangements for its disposal.

Once field activities were completed, the waste was taken to the Cheyenne ANGB, Cheyenne, Wyoming, where it was received and stored. Since no contamination above the analytical detection limit for BTEX (.05 ppm), gas range TPH (10 ppm), or diesel range TPH (20 ppm) was identified at the site, the drum was labeled as non-hazardous waste.

It is recommended that the Colorado ANG contact the local sanitary department, present the analytical findings, and obtain permission to discharge the decontamination water into the sewer system.

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SECTION 5.0 ASSESSMENT FINDINGS

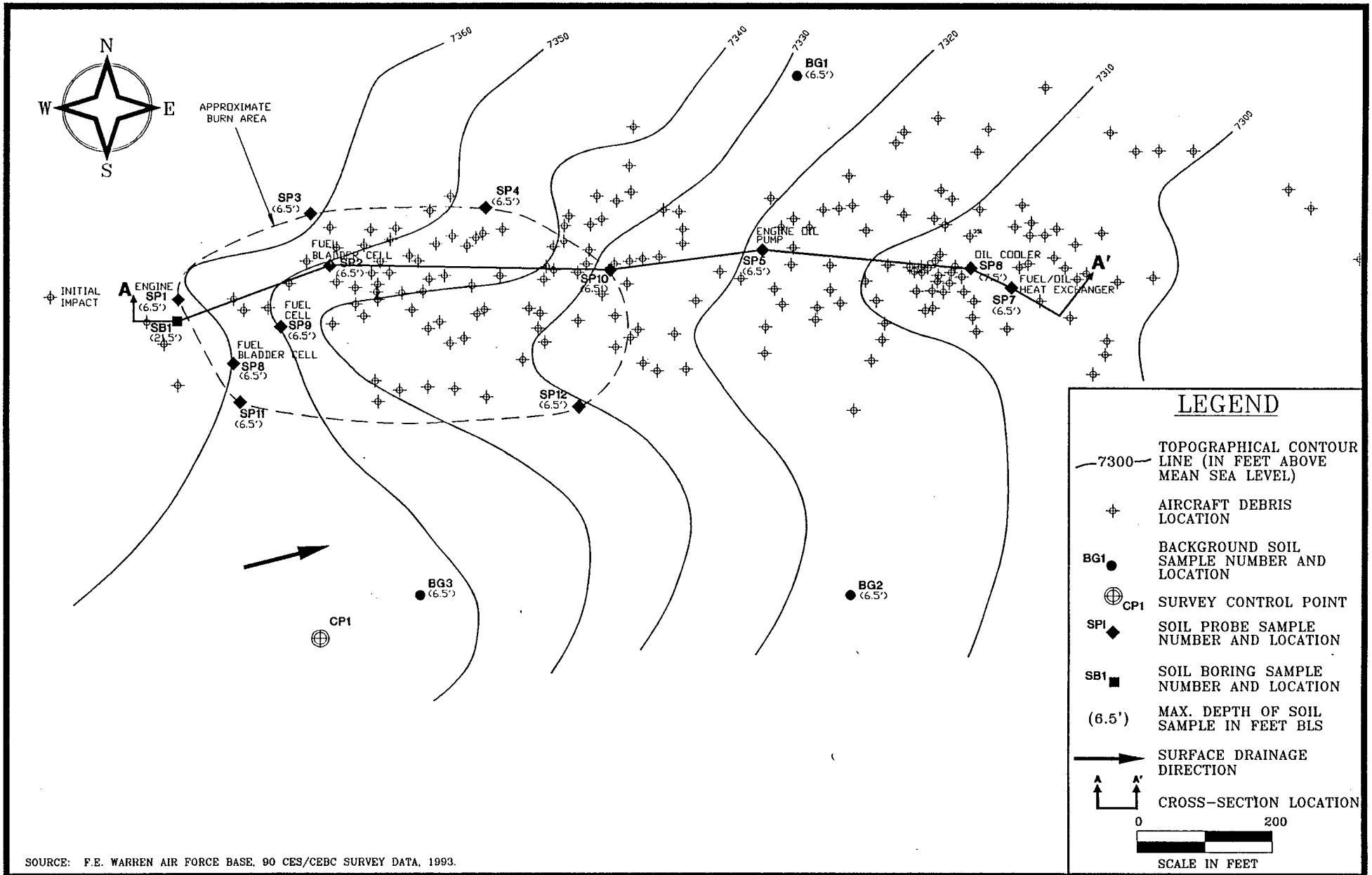
5.1 GEOLOGIC AND HYDROGEOLOGIC OBSERVATIONS

Light to medium brown clay with little fine- to medium-grained quartz sand was encountered from the surface to a depth of five feet BLS at most locations. An olive brown clay with fine- to medium-grained quartz sand with traces of iron oxide staining was encountered six feet BLS at SP6. Gravel consisting of quartz, granite, and chert pebbles with fine-to-very-coarse-grained quartz sand and trace clay was encountered from 5.0 to 6.5 feet BLS at SB1 within a sandy loam lense. The sandy loam lense consisted of fine- to medium-grained quartz sand with little clay and was encountered 1.5 to 16.5 feet BLS. Saturated conditions were not encountered to a depth of 20 feet BLS. Geologic cross-section A-A', depicting the subsurface geology, is indexed in Figure 5.1 and shown in Figure 5.2. Geoprobe Boring Logs are presented in Appendix D.

5.2 SUMMARY OF ASSESSMENT FINDINGS

The field assessment at the Albany County Crash site consisted of 13 site sample locations to delineate BTEX and TPH contamination and 3 background sample locations to establish background soil conditions. These sample locations are shown in Figure 5.1. Of the various aircraft debris locations shown in Figure 5.1, those that were believed to posses the greatest potential for contaminant release, (e.g., engine, fuel bladder, etc.), were designated as sample points. The remaining debris locations, those not designated as sample points, have been left on Figure 5.1 to provide a "to-scale" perspective of the site through the fall-out pattern of aircraft debris.

Soil obtained from each sample location was analyzed to determine the areal and vertical extent of contamination. Sampling locations were designated as SP1 through SP12. Soil samples for SP1 through SP12 were taken at the surface and at five feet BLS. The thirteenth sample location was designated SB1 to differentiate it from the first 12 locations. Soil samples for SB1 were taken at the surface, at 5 feet BLS, 10 feet BLS, 15 feet BLS and at 20 feet BLS. The three background locations were designated as BG1 through BG3. Soil samples for BG1 through BG3 were taken at the surface and at five feet BLS. Field screening included screening the probe hole with the PID immediately after extracting the soil sample and conducting ATHA. Samples were also prepared for mobile laboratory analysis. Results from these analyses are outlined in Section 5.4.2.



SOURCE: F.E. WARREN AIR FORCE BASE, 90 CES/CEBC SURVEY DATA, 1993.

FIGURE 5.1

LOCATION OF GEOLOGIC CROSS-SECTION A-A'

F-16 Crash Site
Albany County, Wyoming

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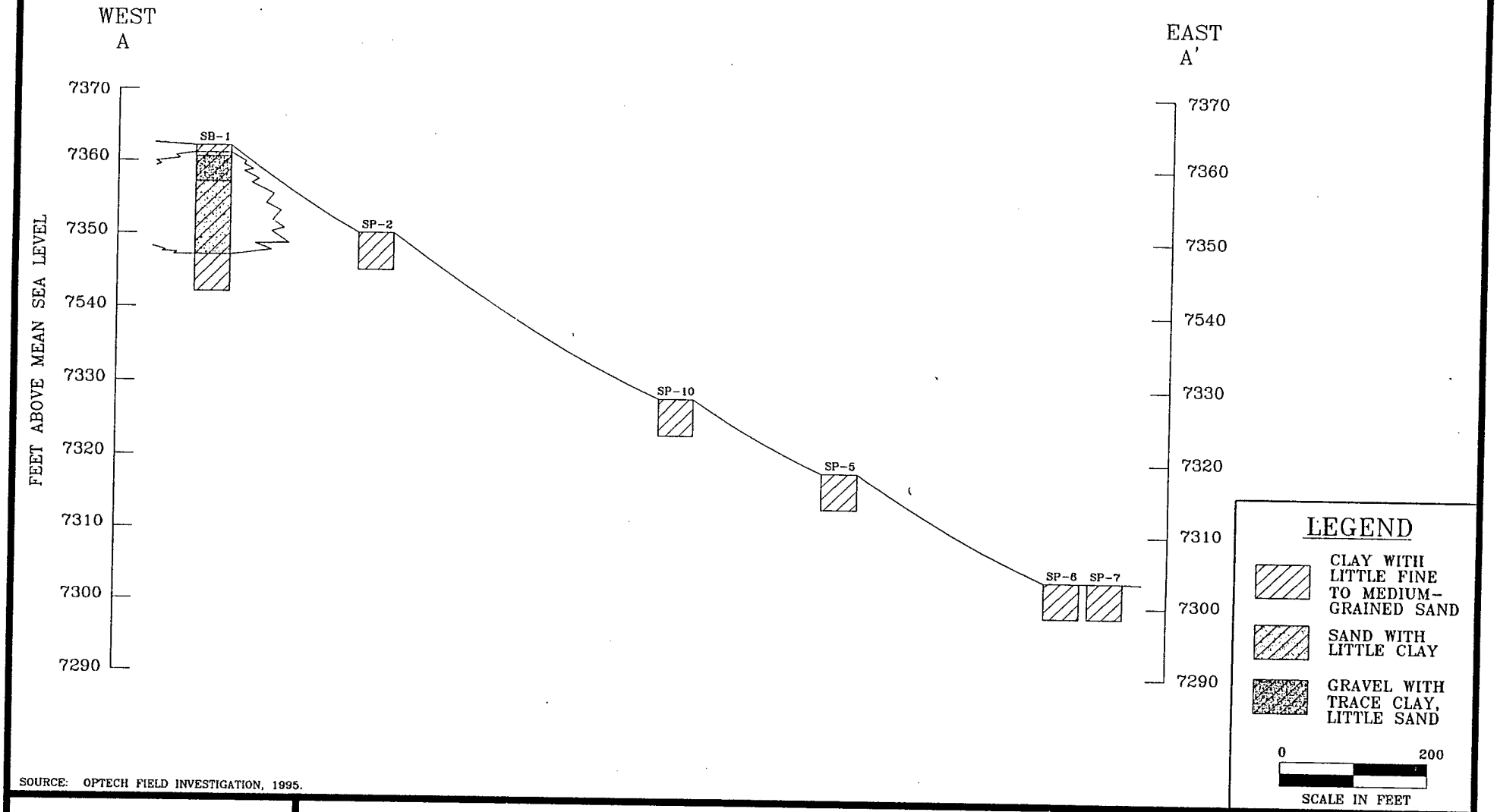

SOURCE: OPTECH FIELD INVESTIGATION, 1995.

FIGURE 5.2

WYOMING\CROSS

GEOLOGIC CROSS-SECTION A-A'

F-16 Crash Site
Albany County, Wyoming

OPTECH
OPERATIONAL TECHNOLOGIES CORPORATION

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Analytical results of all 24 samples fell below the analytical detection limits for BTEX (0.05 ppm), gasoline range TPH (10.0 ppm), and diesel range TPH (20.0 ppm).

5.3 BACKGROUND SAMPLING RESULTS

Background data obtained during the SA was collected from three sample locations. BG1 is located approximately 250 feet north of SP5, BG2 is located approximately 500 feet southwest of SP6, and BG3 is located approximately 440 feet southeast of SP8 (see Figure 5.1). All three background locations were topographically upslope from the initial impact point, and did not show any evidence of being affected by the aircraft impact. Two samples were taken from each background sampling location; one from the surface and one at five feet BLS.

Field screening and ATHA conducted on all background samples indicated no VOCs in the soil at the surface or at five feet BLS, with the exception of the surface sample at BG3. At BG3, ATHA indicated volatile component levels of 0.7 ppm. Table 5.1 shows those background soil samples which had a detectable initial PID or ATHA reading.

Table 5.1
Background Soil Sample Field Screening Results
F-16 Crash Site, Albany County, Wyoming

Sample Location/ Interval (Ft.)	Initial PID Readings (ppm)	ATHA Results (ppm)
BG3 (0-1.5)	0.0	0.7

ppm – Parts per million.
BG – Background soil sampling location.
PID – Photoionization detector.
ATHA – Ambient temperature headspace analysis.
Ft – Feet.

Mobile laboratory analysis of background samples indicated that TPH and BTEX are not present above detection limits in the soils surrounding the site.

5.4 SITE FINDINGS

5.4.1 Screening Results

PID and ATHA analyses were conducted on all samples as described previously in Section 4.4. Only those results with hits are presented in Table 5.2.

Table 5.2
Site Field Screening Results
F-16 Crash Site, Albany County, Wyoming

Sample Location/ Interval (Ft.)	Initial PID Readings (ppm)	ATHA Results (ppm)
SP1 (0-1.5)	0.0	9.0
SP1 (5-6.5)	0.1	0.4
SP2 (0-1.5)	0.0	0.1
SP3 (0-1.5)	0.0	0.3
SP4 (0-1.5)	0.0	0.1
SP4 (5-6.5)	0.3	0.0
SP6 (0-1.5)	0.0	0.1
SP6 (5-6.5)	0.0	0.1
SP7 (0-1.5)	0.0	0.1
SP7 (5-6.5)	0.1	0.0
SP9 (0-1.5)	0.0	63.0
SP9 (5-6.5)	0.3	159.0
SP10 (0-1.5)	0.0	2.0
SP12 (0-1.5)	0.0	1.3
SP12 (5-6.5)	0.0	0.3

ATHA – Ambient temperature headspace analysis.
Ft – Feet.
PID – Photoionization detector.
ppm – Parts per million.
SP – Sampling point.
U – Indicates compound analyzed for but not detected.

5.4.2 Analytical Results

Samples were collected from the surface and at five feet BLS for the 12 primary sample locations (SP1 through SP12). Analytical results of all 24 samples fell below the analytical detection limits for BTEX (0.05 ppm), gasoline range TPH (10.0 ppm), and diesel range TPH (20.0 ppm).

The thirteenth sample location (SB1) was pushed to a depth of twenty feet BLS. Samples were taken from the surface, at five feet BLS, 10 feet BLS, 15 feet BLS and at 20 feet BLS. Analytical results of all five samples also fell below the same analytical detection limits for BTEX and TPH.

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SECTION 6.0 CONCLUSIONS

A total of 16 sample locations were used to identify and characterize soil contamination at the F-16 Crash site. Analysis of soil samples for BTEX and gasoline and diesel range TPH, at every sample location, indicated that these contaminants are not present above detection limit in the soils at the site. Furthermore, no groundwater was encountered to a depth of 20 feet BLS. This indicates that groundwater contamination was not possible at the site.

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SECTION 7.0 RECOMMENDATIONS

Based on the analytical results of the SA, the following recommendation is presented:

- No further action is required.

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